CLAIMS

1. An apparatus for interfacing the motion of an object with an electrical system comprising:

a gimbal mechanism including a plurality of members and providing two revolute degrees of freedom to an object about two axes of rotation, said object being coupled to said gimbal mechanism at an intersection of said two axes of rotation;

a linear axis member coupled to said gimbal mechanism at about said intersection of said two axes of rotation capable of being translated along a linear third axis in a third degree of freedom, wherein said object is coupled to said linear axis member and is translatable along said third axis; and

a first degree of freedom transducer coupled between two of said members of said gimbal mechanism;

whereby said transducer provides an electromechanical interface between said object and said electrical system.

2. An apparatus as recited in claim 1 wherein said gimbal mechanism is a five member linkage.

3. An apparatus as recited in claim 2 wherein said five member linkage includes:

a ground member coupled to a ground surface;

first and second extension members, each extension member being coupled to said ground member;

first and second central members, said first central member having an end coupled to said first extension member and said second central member having an end coupled to said second extension member, wherein said central members are coupled to said linear axis member at ends not coupled to said extension members.

4. An apparatus as recited in claim 3 wherein said first extension member, said first central member, and said second central member are capable of being rotated about said first axis, and

said second extension member, said second central member, and said first central member are capable of being rotated about said second axis.

5. An apparatus as recited in claim 1 wherein said transducer includes an actuator for imparting a force along said first degree of freedom in response to electrical signals produced by said electrical system.

6. An apparatus as recited in claim 5 wherein said transducer includes a sensor for sensing positions of said object along said first degree of freedom and which produces electrical signals corresponding to such positions for said electrical system.

7. An apparatus as recited in claim 1 further comprising a second degree of freedom transducer, said first degree of freedom transducer and said second degree of freedom transducer being coupled between a ground member of said gimbal mechanism and an extension member of said gimbal mechanism.

8. An apparatus as recited in claim 1 further comprising:

a second degree of freedom transducer coupled between two of said members of said gimbal mechanism; and

a third degree of freedom transducer coupled between said linear axis member and said gimbal mechanism.

9. An apparatus as recited in claim 8 wherein said linear axis member provides a fourth degree of freedom about a fourth axis of rotation, said fourth axis of rotation being parallel to said linear axis member.

10. An apparatus as recited in claim 8 further comprising a fourth degree of freedom transducer coupled between said linear axis member and said gimbal mechanism.

11. An apparatus as recited in claim 9 further comprising a floating gimbal mechanism coupling said linear axis member to said object to provide rotational movement for said object along a fifth degree of freedom.

12. An apparatus as recited in claim 11 further comprising a fifth degree of freedom transducer coupled between said linear axis member and said floating gimbal mechanism.

13. An apparatus as recited in claim 12 wherein said object is rotatable about a longitudinal sixth axis of said object to provide a sixth degree of freedom for said object, and further

comprising a sixth degree of freedom transducer coupled between said object and said gimbal mechanism.

14. An apparatus as recited in claim 12 wherein said object includes a stylus.

15. An apparatus as recited in claim 8 wherein said object includes at least a portion of a surgical instrument.

16. An apparatus as recited in claim 1 wherein said object includes a joystick.

17. An apparatus as recited in claim 6 wherein said electrical system includes a digital processing system.

18. An apparatus for interfacing the motion of an object with an electrical system comprising:

a gimbal mechanism providing two revolute degrees of freedom to an object engaged with said gimbal mechanism about two axes of rotation, said object being coupled to said gimbal mechanism at about the intersection of said two axes of rotation;

a transducer coupled to said gimbal mechanism to generate a force along said first degree of freedom; and

a capstan drive mechanism coupled between said actuator and said gimbal mechanism, said capstan drive mechanism transmitting said force generated by said transducer to said gimbal mechanism and transmitting forces applied to said gimbal mechanism by a user to said transducer;

whereby said actuator provides an electromechanical interface between said object and said electrical system.

19. An apparatus as recited in claim 18 further comprising a linear axis member coupled to said gimbal mechanism at said intersection of said two axes of rotation capable of being translated along a third axis in a third degree of freedom, wherein said object is coupled to said linear axis member and is translatable along said third axis.

20. An apparatus as recited in claim 19 further comprising a second degree of freedom transducer coupled to said gimbal mechanism to generate a force along said second degree of freedom and sense movement of said object along said second degree of freedom.

21. An apparatus as recited in claim 20 further comprising a third degree of freedom transducer coupled between said gimbal mechanism and said linear axis member to generate a force along said third degree of freedom and sense translation of said linear axis member.

22. An apparatus as recited in claim 19 wherein said gimbal mechanism includes a closed loop five member linkage.

23. An apparatus as recited in claim 19 wherein said capstan drive mechanism includes an rotating capstan drum rotatably coupled to said gimbal mechanism, said capstan drum being additionally coupled to a pulley by a cable, wherein said transducer is operative to rotate said pulley and thereby transmit force to said gimbal mechanism with substantially no backlash.

24. An apparatus as recited in claim 19 further comprising a second transducer and a second capstan drive mechanism coupled between said second transducer and said gimbal mechanism, said second capstan drive mechanism transmitting a force generated by said second actuator to said gimbal mechanism and transmitting a force applied to said gimbal mechanism by a user to said transducer.

25. An apparatus as recited in claim 19 further comprising a third axis capstan drive mechanism for transmitting forces between said third degree of freedom transducer and said linear axis member.

26. An apparatus as recited in claim 24 further comprising a plurality of sensors coupled to said apparatus to sense positions of said object along said three degrees of freedom and which produce electrical signals corresponding to such positions for said electrical system.

27. An apparatus as recited in claim 26 wherein said object includes one of the groups consisting of at least a portion of a surgical tool, a stylus, and a joystick.

28. An apparatus as recited in claim 26 wherein said apparatus includes a sensor for sensing positions of said object along a fourth degree of freedom, said fourth degree of freedom being rotation about said translational axis of said linear axis member.

29. An apparatus as recited in claim 26 wherein said apparatus includes a sensor for sensing positions of said object along a fifth and sixth degrees of freedom, respectively, said fifth and sixth degrees of freedom being provided as rotation of said object about an end of said linear axis member, and rotation about a longitudinal axis of said object, respectively.

30. An apparatus as recited in claim 26 wherein said electrical system includes a digital processing system.

31. An apparatus as recited in claim 30 wherein said actuators are DC servo motors controlled by linear transconductance amplifiers.

32. An apparatus as recited in claim 31 wherein said digital processing system includes a digital-to-analog converter for providing an analog voltage for controlling said linear transconductance amplifiers.

33. A method for interfacing motion of an object with an electrical system, the method comprising the steps of:

defining an origin in 3-dimensional space;

providing a gimbal mechanism movable relative to said origin in said 3-dimensional space such that an object engaged with said gimbal mechanism has first and second degrees of freedom;

providing a translatable member to move said object in a third degree of freedom;

transducing an electrical signal for each of said three degrees of freedom using first, second, and third transducers, respectively, wherein two of said transducers are decoupled from each other; and

providing said electrical signals to and from said electrical system.

34. A method as recited in claim 33 wherein said electrical system is a digital processing system.

35. A method as recited in claim 34 wherein said gimbal mechanism is a closed loop five member linkage.

36. A method as recited in claim 34 wherein said first and second degrees of freedom of said object are provided by rotating members of said five member linkage about first and second axes of rotation, respectively.

37. A method as recited in claim 36 wherein said step of transducing an electrical signal for each of said three degrees of freedom includes converting output signals from said digital processing system into movement of said object.

38. A method as recited in claim 37 wherein said step of transducing an electrical signal for each of said three degrees of freedom includes converting movement of said object into electrical input signals which are input to said digital processing system.

39. A method as recited in claim 38 further comprising a step of transducing an electrical signal for a fourth degree of freedom of said object using a fourth transducer, said fourth degree of freedom being provided by rotating said object and said translatable member about a transverse axis of said translatable member.

40. A method as recited in claim 39 further comprising a step of transducing an electrical signal for a fifth degree of freedom of said object using a fifth transducer, said fifth degree of freedom being provided by rotating said object with respect to an end of said translatable member.

41. A method as recited in claim 40 further comprising a step of transducing an electrical signal for a sixth degree of freedom of said object using a sixth transducer, said sixth degree of freedom being provided by rotating said object about its own lengthwise axis.

42. A method as recited in claim 39 further comprising transmitting a force from an actuator to said gimbal mechanism using a capstan drive mechanism.

43. A method as recited in claim 33 wherein said translatable member is a linearly extending rod.

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